International Journal of All Research Education and Scientific Methods (IJARESM),
ISSN: 2455-6211, Volume 13, Issue 5, May-2025, Available online at: www.ijaresm.com

# Does a Picture Book Help Children to Build a Love for Mathematics? : A Review

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## ABSTRACT

**Early mathematics education helps children to improve math literacy and the use of picture books can be an effective way to improve students' mathematics development. This paper sheds light on international studies conducted on the use of picture books to teach mathematics to children. The benefits of utilizing children's picture books to teach mathematics also thoroughly specified. The various studies on the selection criteria also mentioned. The statistics of studies on the use of picture books specifically on general math concepts, arithmetic concepts and geometrical concepts reviewed here. The paper emphasizes some suggestions regarding further research to strengthen children's mathematics concepts. Most of the reviewed studies conclude about the positive impact of picture books to mathematical achievement of children and encouraged the use of such learning processes to increase children's love of mathematics. There is a need of such type of studies to be conducted in India to motivate Indian children in mathematics learning.**

**Keywords: Introduction, Benefits Of Use Of Picture Books, Selection Criteria, Mathematics With Picture Books, Statistics, Suggestions And Conclusion**

## INTRODUCTION

"Without mathematics, there's nothing you can do. Everything around you is mathematics. Everything around you is numbers."- Shakuntala Devi

It is truly said by Shakuntala Devi that math is all around everybody. Usually children do not recognize that mathematics is all around them. They learn and develop the basics of mathematics through their daily activities. When they are playing with their toys, counting toffees, collecting different shapes of leaves, sorting various items, noticing shapes and patterns, comparing quantities etc., they are gathering knowledge of simple or basic mathematics. The foundation of children's mathematical development is mainly based on these everyday experiences with their strong desire to know the things. So before going to school, children start learning mathematics. Early mathematics education helps children to improve math literacy and also increase the quality of the mathematics classroom environment. The National Council of Teachers of Mathematics (NCTM) and the National Association for the Education of Young Children (NAEYC) affirms that high-quality, challenging and accessible mathematics education for 3- to 6-year-old children is a vital foundation for future mathematics learning. NCTM introduced the use of children's literature within the mathematics instruction in 1989.Author Marilyn Burns expresses her thoughts as "I think that children's literature offers a wonderful vehicle for helping teachers teach math well."

This article attempts to focus on the impact of the usage of picture books with the purpose of teaching mathematical concepts to children. The numerous studies confirm that employing these in math lessons can spark the imagination of students in such a way which traditional exercises do not. 'Picture books' means, books containing text and pictures in which pictures have an essential role in full communication and understanding (Nikolajeva and Scott 2000). This article tries to give a brief sketch of the studies done in the field of Mathematics education specifically through the picture books and also to introduce children various math disciplines. The effort is to summarize the statistics about studies specifically on general math concepts, arithmetic concepts and geometrical concepts. For this purpose, the survey of the related literature has been done mainly through various research articles published in educational journals, books, dissertations and theses, the websites and blogs on related topic.

### Benefits of utilizing children's picture books to teach mathematics

Using children's literature in math lessons can enhance learning ability of children in many ways. When a child can make a math connection in a story, poem, pictures etc., it becomes more interesting to learn mathematics and connect it with their daily activities. Many picture books can be used as a starting point for doing math activities in a supportive

and interesting environment to increase learning ability in mathematics. Some of the benefits of mathematics learning through children's picture books are as follows:

- Children feels that math is not boring and understand the math concepts in a risk-free environment
- Develop the number sense in children
- Children easily understands the math concepts and contexts in a motivating manner
- Picture books provides visualization of mathematical concepts in the illustrations
- Sparks child's curiosity to explore the mathematical ideas through the combination of illustrative literature and mathematics
- Children become confident in their ability to do mathematics
- Helps students to build problem solving skills
- Encourages the intellectual thinking and level of interest of the children
- Helps many children to draw their attention to literature from a very young age
- Maths through interesting illustrative stories eliminates the myth that mathematics is difficult, unimaginable, complicated etc.
- Enables student to understand the process of applying Mathematics to solve real life problems
- A win-win situation for children and for teachers because books becomes extremely an effective tool to teach mathematics for teachers
- Children's books serves as a great motivator to learn mathematics

**Some basic points to be considered before selecting a book**

Though children's literature fosters child's healthy development in all of its aspects, it is a very tough and challenging task to choose the proper book from the thousands of publications. The selection of a book requires thoughtful attention because it is an immeasurable investment in the human mind. Various mathematical standards were developed to evaluate the mathematical and literary value of books (NCTM standards, 1989 and 2000; Schiro, 1997; Hellwig, Monroe and Jacobs, 2000; Whitin and Whitin, 2001; Hunsader, 2004; Halsey, 2005). Classification schemes provided with selection criteria of the children's books in teaching and learning mathematics (Whitin and Whitin, 2004; Marston and Mulligan 2012; Cianciolo, 2000). Guidance for the worthy books to be used in mathematics education (Shih and Giorgis, 2004; Roth McDuffie and Young, 2003; Forrest, Schnabel and Williams, 2006; Dunphy, L., 2020;Cotti and Schiro, 2004), investigation of mathematical content in illustrated children's books (Genc, Cosgun and Sengul, 2017), offers a framework of learning-supportive characteristics of picture books (Van den Heuvel-Panhuizen and Elia, 2012; LeSage, A. C., 2013).Some of the basic points before selecting or buying books are –

- Examine and ensure that the chosen book is appropriate for the age level for whom it is being selected
- Check if the content in the book is mathematical and able to solve the child's curiosity
- Confirm the category of the books as per the child's reading interests and needs
- Ensure that the mathematical components of the book are accurate?
- Make sure that the contents of the book perfectly woven into the illustrated narrative which can easily introduces the mathematical ideas to hold child's attention
- Do the survey of the recommended list of books for children in different lessons of mathematics.
- Check the titles of the most circulated books in the library
- Confirm that the selected book is able to encourage a child to think, to question, to stimulate his curiosity, to evaluate values and assumptions for themselves?
- Identify that the selected book promotes healthy mathematical attitudes and concepts and are those accessible to the reader?
- Refer an annotated bibliographies of children's literature for additional assistance
- Check the catalogue of the renowned publishers for the latest publications
- These are some basic points which may helpful to choose a book for your kid. Finally, it will be the collective effort of the teacher, parent and student to select and utilize literature to enhance mathematical skills and understanding.

**Studies related to the use of picture books to teach Mathematics – at a glance**

Many studies have been conducted to establish that the use of the children's literature to teach mathematics definitely build a love of mathematics in children and are very constructive and effective. Teachers, who integrate literature into mathematics, can develop important problem solving abilities in their students that will continue to assist them throughout life (Moyer, 2000).As Moyer points out, integrating literature into a mathematics curriculum is a successful way of developing a positive environment in the classroom and improving students' attitude towards mathematics. The NCTM also supports the integration of children's literature (of any genre) into mathematics classroom to provide relevance and show problem solving techniques. Stone, Jessica (2016) stated the history of the use of picture books in

mathematics education in brief and points out that Beard and Whitaker took a first move to encourage this idea through their articles published in 1962, the same emphasized by Far in 1979 but the logic behind the use of picture books in mathematics instructions were highlighted by Radebaugh in 1981. NCTM specifically advocates the thought of using children's books in the curriculum in 1989. In the area of Mathematics there are plenty of research works employing picture books of children. Although it is practically impossible to investigate all relevant studies on this topic, some of them are reported here –

**Studies on the effect of picture books to understand General Math Concepts**

Mathematics is a basic core subject and at the elementary level the foundation of this subject must be strong. Use of picture books is an easy way to introduce children to mathematical concepts in a meaningful and appropriate way and to support children's mathematical studies.

Van den Heuvel-Panhuizen, Elia and Robitzsch (2016) investigate the largest study with 384 children from 18 kindergarten classes in Netherland using pretest–posttest method. The data analysis provides the evidences about a positive effect of picture book reading with 22% of increase marked in posttest as compared to pretest and appears to be beneficial for girls to understand the mathematical concepts. Stone, Jessica (2016) also analyzed the data of 136 students representing the minority backgrounds into two groups-control group with regular mathematics curriculum and treatment group with teaching one picture book per week. The study revealed a remarkable mathematical achievement by the students in the treatment group. Van den Heuvel-Panhuizen, M. (2015) discusses about the project of using picture books to support kindergartners' development of mathematical understanding carried out at Freudenthal Institute on elementary mathematics education. Parent/child shared picture book reading also supports mathematical thinking (Anderson, J., Anderson, A., and Shapiro, J., 2000; Welchman-Tischler, R., 1992).

Van den Heuvel-Panhuizen, Van Den Boogaard and Doig (2009) carried out a study as part of *Picture book and Concept development in mathematics (PICOma)*project of reading sessions with children in Netherland to experience the various mathematical concepts of data handling, time-length graph, measurement etc. The use of picture books with a learning environment helps children to explore their mathematics-related concepts (O'Neill, Pearce, and Pick 2004; Jennings et al., 1992; Attard, Catherine, 2017; Shih and Giorgis, 2004; Young-Loveridge, 2004; Hong, 1996; Casey et al., 2008; Van den Heuvel-Panhuizen and Elia, 2011; Van den Heuvel-Panhuizen, Elia, and Robitzsch, 2008; Whitin, 1992), supportive for understanding the context meaningfully (Arnheim, 1993), build good perception with a new knowledge (Lovitt, C., and D. Clarke., 1992). The power of reading illustrated children's books introduces children to the concepts of mathematics and raises awareness of mathematics in an understandable and memorable way (Barnby, 2015; Goral and Gnadinger, 2006; Griffiths and Clyne, 1991; Van den Heuvel-Panhuizen M. and Elia I., 2013; Murphy, S.,1999 and 2000; Butterworth and Cicero, 2001; Shatzer, J., 2008; Anderson, Anderson and Shapiro, 2005; Dunphy L., 2020), children's spontaneous mathematical cognitive ability (Elia, Van den Heuvel-Panhuizen and Georgiou, 2010), provides opportunities for problem solving (Schiro, 1997; Columba, Kim and Moe, 2005; White, Jeanne, 2017; McCredie, Jennifer, 2013), use of picture books in teachers training in mathematics activities (Flevares, L. M., and Schiff, J. R., 2014). Meaningful representation of illustrations in the text plays an important role in development of mathematical concepts (Kress and van Leeuwin, 1996; Lewis, 2001; Roth McDuffie, A. M., and Young, T. A., 2003), solution of the different ways to connect words and illustrations in constructive sense (Wolfenbarger and Sipe 2007). Narrative-First Approach of the picture-story book to represent the themes, characters through mathematical lens to engage teachers and students to energize the mathematics classroom (Russo and Russo, 2017a, 2017b, 2017c, 2017d, 2017e, and 2018), discusses about how the picture books can help teachers to engage children with energetic mathematical ideas (Muir and others, 2017; Jenkins, K., 2010; Burns, Merilyn, 2010; Cotti and Schiro, 2004), inspire educators to use and select appropriate picture books to teach math to children (Shatzer, 2008; Thiessen 2004;Marston, J., 2014; Marston, J., 2010; Marston, Muir and Livy, 2013). From the investigation of the above studies, it can be stated that the inclusion of picture books in the mathematics learning would be an intriguing step to alleviate math anxiety in children, but it depends entirely on how the teachers/parents teach.

**Studies on the use of picture books to understand Arithmetic Concepts**

Understanding of the arithmetic concepts serves as a base for children's primary mathematical skills. But a healthy educational environment is needed to make children aware of these concepts. There are many studies on the effect of the use of picture books to understand these arithmetic concepts to children.

The article 'Counting in Children's Picture Books: Digging deeper' by Perger and Major (2018) dealt with the demonstrations about the counting principles in picture-books. The ordinal, measure and non-numerical context have been evidently pointed out in the picture book. Also explains the meaning of numbers as indicators rather than a numerical value. The study concludes that children's picture-books are able to provide a meaningful context for children to practice their counting skills. Marston, Muirand Livy (2013) stressed upon the incorporation of picture books into mathematics primary classroom to analyze number concept. Similar studies which assesses the mathematics-related statements of children about counting, numerosity during book reading activity (Van den Heuvel-Panhuizen,

Elia, and Robitzsch, 2016; Van den Heuvel-Panhuizen and Van den Boogaard, 2008; LeSage, A. C., 2013), introduces number related topics in a simple and sophisticated manner (Griffiths and Clyne, 1991; Thiessen, Matthias, and Smith, 1998; Willis, S., 2002), investigation through a picture book entitled "What are the numbers?" made up flora and fauna in Borneo on reading and writing numerals up to 20 and feedback from teachers and parents on the its usage (Ompok, C. C. et al., 2018), illustrations gives an opportunity to count the animals by applying the heterogeneous and homogeneous groups of animals (MacIellan, 1997), story and illustrations helps children to consolidate their counting knowledge (Perger, 2017), helps children to understand the concept of big numbers (Milbourne and Riglietti, 2007), use of picture book with hands-on activities to introduce multiple representations of place value and base-ten number system to children (Kim, Y. R., and Park, M. S., 2018), reading and teaching a story by displaying accompanying pictures had a positive effect on students' achievement in fractions (Lemonidis and Kaiafa, 2019; Young,2001; Mink and Fraser, 2005; Jennings et al., 1992; Bintz et al., 2011).

Some other investigative studies on Spontaneous Focus On Numerosity (SFON) (Hannula et al., 2010; Rathé, S. et al., 2016; Hannula-Sormunen et al., 2015; Hannula, Räsänen, and Lehtinen, 2007; Hannula and Lehtinen, 2005;Edens and Potter, 2013) reports inter-individual differences in children's SFON scores, SFON using a picture-matching task (Chan and Mazzocco, 2017). Hannula and colleagues (2005)and Rathé, S. et al. (2016) offers building blocks to encourage children's focus in numbers, counting etc. through daily life activities. Also studied the relationship between kindergartners' SFON and their number-related comments during numerical picture book reading. The better understanding of cardinality concept reported in children (Gelman et al., 2005),investigation by pretest-intervention-posttest method with 39 children (3-4 years age) by the intervention of picture books (Peterson et al., 2014).White, Jeanne (2017) perfectly explains in the book about the arithmetic ideas of place value, counting natural numbers, fractions, percentages, decimals, addition, subtraction, multiplication and division by using some picture books to introduce elementary students. Therefore, all the studies conclude a positive impact of picture books to understand arithmetic concepts.

**Studies on the use of picture books to understand Geometrical Concepts**

Geometry is basically the study of points, lines, angles, surfaces and solids that is overall study of all shapes and figures. It is suggested that geometry instruction has to begin early; children need to teach in a different mode rather than regular school syllabus. In this regard, some of the studies have the opinion that the use of picture books helps in understanding the geometrical concepts to children.

Skoumpourdi and Mpakopoulou (2011) assesses the impact of picture book to introduce geometric shapes to children by conducting pre-test (supplying a questionnaire) and post-test (through a picture story book 'The Prints') with 18 children of 5 years of age (9 girls and 9 boys) in a kindergarten school. The post-test result shows that children can identify prints of solid shapes through picture book and link the plane figures with prints of solids real life objects as compared to pre-test. The study concludes that knowing the relationship between the connections of plane figures and solid shapes means understanding geometrical concepts.

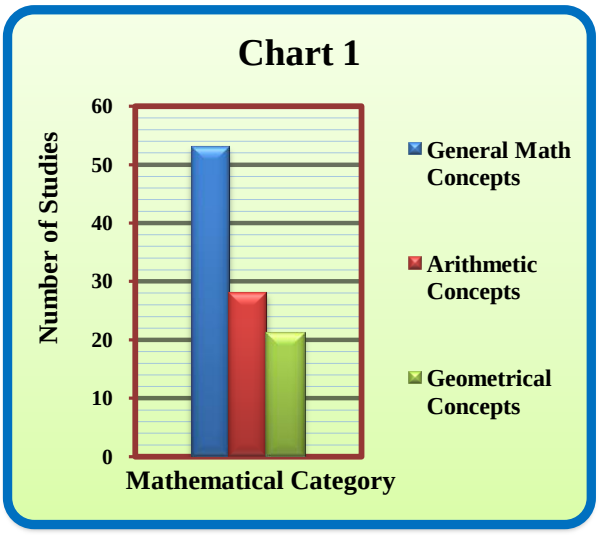
Some studies support the effective use of picture books to understand the geometrical ideas (Van den Heuvel-Panhuizen and Van den Boogaard, 2008; Griffiths and Clyne, 1991; Preissler and Carey, 2004; Van den Heuvel-Panhuizen, Elia, and Robitzsch, 2016; Muir and others, 2017; White, Jeanne, 2017; Minetola, Serr and Nelson, 2012), study by composing geometrical puzzles (Casey et al., 2008),recommendations for accurate professional development of a teacher's geometric knowledge (Clements and Sarama, 2011; Flevares and Schiff, 2014).

Effective conceptual connection of the visualized powerful examples of the two-dimensional shapes of the pictures to the activities in their three-dimensional environment (Minetola et al., 2012; Van den Heuvel-Panhuizen et al., 2009). Some of the studies stated regarding the leading misconceptions about the geometrical concepts in children due to the representation of prototypical shapes in books or puzzles or inadequate teacher training and professional development (Chard et al., 2008; Clements et al., 1999; Oberdorf and Taylor-Cox, 1999; Hannibal, 1999; Clements and Sarama, 2000; Inan and Dogan-Temur, 2010), a barrier to children's capability to use picture books symbolically (Simcock and DeLoache, 2006; Strouse, Nyhout and Ganea, 2018).So, it can be stated that the use of mathematics-related literature can improve students' attitude towards geometry and achievement in geometry. Whereas some of the studies raise awareness about unskilled professionals and misrepresentation of shapes in books which mislead students.

**Statistics of the above studies on General Math Concepts, Arithmetic Concepts and Geometrical Concepts by using picture books to teach mathematics to children**

This section presents the statistics of the results with percentage acquired with respect to studies reviewed on the mathematical categories:

International Journal of All Research Education and Scientific Methods (IJARESM),
ISSN: 2455-6211, Volume 13, Issue 5, May-2025, Available online at: www.ijaresm.com



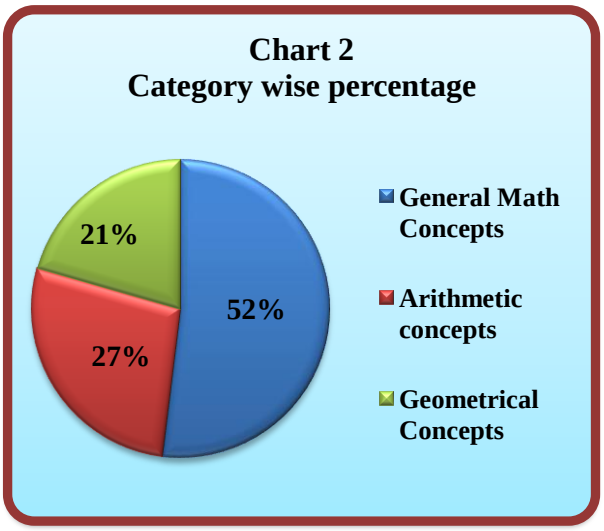




Chart 1 show that the total numbers of studies done on the General Math Concepts are 53. It is followed by 28 studies on Arithmetic Concepts and 21 studies conducted on Geometrical Concepts. Percentage wise statistics in Chart 2 shows that the studies on General Math Concepts category appears with major contribution of 52%, Arithmetic Concepts having 27% and the studies on Geometrical Concepts show the least of 21%.The reviewed studies shown that the number of research in general mathematics is high, but the number of research in geometric concepts is minimal. The number of studies reported in the field of arithmetic concepts and geometric concepts is less-than-equal. The result shown that the studies recorded in a particular mathematics category like arithmetic and geometry are less as compared to the general math conceptions.

The finding of the studies on general math concepts expresses the different modes of mathematics teaching to introduce children to mathematical concepts. The highest number of studies recorded by 'Van den Heuvel-Panhuizen' and 'Russo and Russo' in this field. The largest study investigated by Van den Heuvel-Panhuizen, Elia, and Robitzsch (2016) concludes a positive effect of picture book reading to understand the mathematical concepts by conducting pretest-posttest method. Whereas Russo and Russo stated about the narrative-first approach of picture-story book to motivate students and teachers as well to see the characters from a mathematical angle from 6 of studies. The emphasis was given on the provision of learning environment with picture books to examine children's mathematics-related ideas in 10 studies. The investigation of 12 studies analyzed the power of reading picture book to encourage the mathematical thinking of children. 10 studies discuss and inspire teachers, educators about the proper usage of picture books to engage children in mathematical activities. Remaining studies points out the importance of meaningful representation of illustrations in development of math concepts, use of picture books provides opportunities for problem solving, different ways to connect text and illustrations in a constructive method. Most of the studies reports about the use of picture books to teach mathematics concepts build a love of mathematics in children and helps children to develop their problem solving abilities.

The reviewed studies on the arithmetic concepts shows that most of the studies investigate the effect of picture books to make awareness in children about the numbers, counting and basic arithmetic concepts. The highest number of studies done by Hannula on children's Spontaneous Focus On Numerosity scores. The report of the 5 studies records a positive effect on student's achievement in fractions. The reviewed studies provides different educational modes to understand the arithmetic concepts to children such as demonstrations about counting with picture books, investigates the effect of picture books with the feedback from teachers and parents, provides the hands-on activities to encourage children through daily life activities, assesses the impact by the intervention of picture books to introduce number system, stressed upon the incorporation of picture books into mathematics instructions, explains the use of picture books to help children to understand the basic arithmetic concepts of place value, natural numbers, fractions, decimals etc. All the investigated studies reveals about the positive effect of the use of picture books to know the arithmetic concepts in a healthy educational environment.

The studies of shapes and figures i.e. geometrical concepts records least number of studies as compare to general math concepts. Most of the studies assess the impact of picture book to introduce geometric shapes to children. Among the reviewed studies, seven studies support the effective use of picture books to understand the geometrical ideas. Two studies recommended the professional development of teachers and other two studies reports the effective connection of the two-dimensional shapes of the pictures in the three-dimensional environment. Casey et al., 2008 studied the children's geometrical ideas by composing puzzles. But eight of the studies express the leading misconceptions about the geometrical concepts due to prototypical shapes, inadequate professional development.

**Suggestions**

After reviewing the above studies on the impact of picture books on teaching mathematical concepts to children and looking at the positive results, here are some suggestions for the further research to note-

- As the investigated studies are limited to general math concepts, arithmetic concepts and geometrical concepts only, there is a need to review the studies conducted specifically on other branches of mathematics like algebra, statistics, data analysis, probability etc.
- The present study is limited to the impact of picture books only, so the role of other various forms of children's literature like poetry, fairy tales, plays, puzzles, books on games etc. in mathematics education also can be reviewed.
- While surveying the literature for the theme of the present paper, it has been noticed that there are reports about the studies in the field of mathematics education in India but those are focusing on the maths curriculum, play way method for teaching mathematics, academic achievement of students in mathematics, factors causing low achievement in mathematics etc. but did not find any studies regarding the use of picture books in mathematics instruction. So it is recommended that researchers examine in detail how illustrated children's books can be used by teachers in mathematics classrooms to encourage mathematical thinking of Indian children.
- Assessing the impact of picture books in Primary, Secondary and Higher Secondary Grades Mathematics Instruction in India can be studied further.
- Most studies show that a picture book has a positive effect on math success in children, but does it apply to different subjects as well?
- Impact of parent-child shared book reading do encourages mathematical knowledge in children?
- There are several studies registered on the selection of children's books to teach mathematics at an international level but it should be reviewed in case of India also.

## CONCLUSION

The foundation of children's mathematical development is mainly based on the teaching environment surrounded by them. NCTM introduced the use of children's literature within the mathematics learning to make this foundation strong. Beard and Whitaker encourage the idea of using picture books in mathematics instructions at the developmental stage of children. The studies conducted suggest that illustrated children's books provide mathematical concepts in a meaningful and healthy environment to understand these concepts. The various benefits of mathematics learning through children's picture books are stated thoroughly. Various studies and basic points for the selection of the children's books are also mentioned.

The analysis of the studies shows that the studies on general math concepts recorded the highest number of studies and those are conducted by 'Van den Heuvel-Panhuizen' and 'Russo and Russo'. The studies conclude the use of picture books in mathematics education enhances learning ability of children. The studies on the arithmetic concepts shows that most of the studies investigate to make aware children about the numbers, counting and basic arithmetic concepts by providing different educational modes and the highest number of studies recorded by Hannula. All the studies in this field concluded that the illustrated children's books foster child's healthy development in the arithmetic concepts. The least number of studies recorded in the field of geometrical concepts and introduces the different shapes to children with the help of picture books. But some of the studies stated about the leading misinterpretation of the illustrations of the geometrical shapes and about the unskilled professionals.

This study shows that efforts have been made internationally to study the effects of picture books to create math interest in children. Except some studies in the area of geometry, all reviewed studies have shown positive results in the use of illustrated books in children's mathematics education. It is recommended that in India also such type of studies should be conducted to give a healthy meaningful learning environment to motivate Indian children in mathematics learning and to reduce their math anxiety.

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